(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 249 107 A2**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 87107812.7

(51) Int. Cl.4: G21C 3/34 , G21C 3/32

(22) Date of filing: 29.05.87

(30) Priority: 11.06.86 US 872988

(43) Date of publication of application: 16.12.87 Bulletin 87/51

(84) Designated Contracting States: BE DE FR GB IT SE

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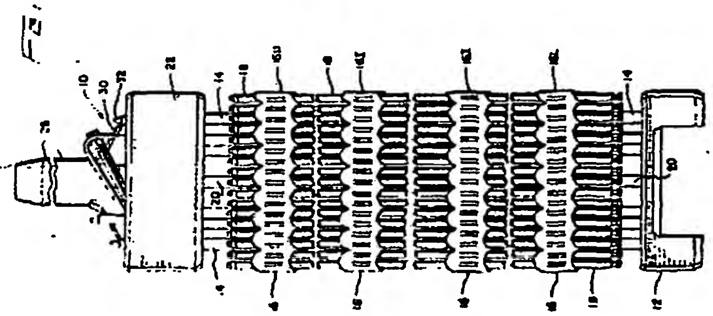
(54) **Nuclear-reactor fuel assembly having a plurality of spacer grids.**

(57) The invention relates to a nuclear fuel assembly having a plurality of fuel-rod spacer grids (16) with detents (46,48) designed to apply to each fuel rod (18) a predetermined force laterally supporting it against displacement and vibration.

The predetermined force designed into the detents of the end grid (16U) nearer the coolant-outlet end structure (22) of the fuel assembly is sufficiently less than the predetermined force designed into the detents of the end grid (16L) nearer the coolant-inlet end structure (12) to permit rectilinear elongation of fuel rods tending to axially grow.

The invention alleviates the problem of fuel-rod bow, especially in conjunction with fuel assemblies having intermediate spacer grids (e.g. of Zircaloy) with detents which are more subject to irradiation-induced spring relaxation than those of the end grids (e.g. of Inconel).



EP 0 249 107 A2

NUCLEAR-REACTOR FUEL ASSEMBLY HAVING A PLURALITY OF SPACER GRIDS

The present invention relates generally to nuclear reactors and, more particularly, to a nuclear-reactor fuel assembly having a plurality of fuel-rod spacer grids.

As well known in the art, the function of spacer or support grids in a nuclear fuel assembly is to keep the fuel rods in the fuel assembly accurately spaced from one another and to laterally support them against vibration. Usually, spacer grids are fabricated from a plurality of metal straps interlaced and interlocked in an egg-grate-like manner so as to form open cells, most of them for receiving fuel rods (standard cells), and some for receiving control-rod guide thimbles (thimble cells). Each fuel rod received in and extending through a standard cell is laterally supported therein by detents protruding from strap portions forming the walls of the cell. Commonly, the detents are formed out of the material of the respective cell-defining strap portions, and comprise grid springs and relatively rigid dimples disposed to react with the grid springs. Fuel-rod spacer grids are disclosed in U.S. patent specifications Nos. 3389056, 3713971, 3944467, 4224107 and 4474730, for example.

Materials commonly used for making spacer grids are nickel-base alloys known as Inconel, and zirconium alloys known as Zircaloy. Inconel is strong and highly corrosion-resistant, and grid springs formed therefrom are relatively insensitive to irradiation-induced relaxation, which is to say, they will not lose their strength to any significant degree when exposed to the intense heat and radiation present in a nuclear reactor core. Zircaloy, on the other hand, has a lower neutron-parasitic cross-section, i.e. is less neutron-absorptive, than Inconel and therefore has gained favor as the grid material to be preferred from a standpoint of better fuel economy; but Zircaloy grid springs are more subject than Inconel springs to irradiation-induced relaxation and, during use thereof, tend to lose almost 30% of their strength initially, and up to nearly 90% of their remaining strength after one year of radiation exposure. Of course, such losses undesirably reduce the spring forces holding the fuel rods in their precise positions and against vibration.

As a compromise optimizing the benefits to be derived from using Inconel on the one hand (strength and relatively low susceptibility to irradiation-induced spring relaxation) and Zircaloy on the other (low neutron parasitic cross-section), it has been proposed to utilize Inconel grids as end grids and Zircaloy grids as intermediate grids. Such an arrangement combines the advantages of relatively high neutron economy as afforded by the Zircaloy intermediate grids employed in the main neutron-flux region of the reactor core, and of consistently firm fuel-rod support as provided by the springs in the Inconel end grids, namely, the lowermost or upstream (having regard to the direction of coolant flow) end grid where consistently strong spring forces are required in order to ensure that no fretting-wear-causing vibration will be induced in the fuel rods by the turbulent coolant flow normally existing near the inlet end of the fuel assembly, and the uppermost or downstream end grid which is located where the higher neutron-parasitic cross-section of Inconel has little effect upon neutron economy, namely, in the gas plenum area of the fuel rods which is outside the actual fuel region of the core.

Such "optimized" fuel assemblies employing Inconel end grids and Zircaloy intermediate grids have proved satisfactory. However, they have been found on occasion to be susceptible to fuel-rod bow due to the following conditions. The fuel-rod detents (springs and dimples) in each grid cell commonly are so located with respect to one another that their forces exerted upon a given fuel rod introduce therein a lateral bending moment. For as long as the grid springs of all spacer grids retain their ability to exert the force initially designed into them, they will ordinarily keep the fuel rods straight, even if the latter tend to axially grow as usually they do during use. However, as the grid springs lose some of their strength during us , and since the Zircaloy springs in the intermediate grids of an "optimized" fuel assembly do so to a much greater extent than the Inconel springs in the end grids, the springs in the end grids will continue to hold the axially growing fuel rods firmly enough to impede elongation thereof, thereby placing them in axial compression, whilst the more relaxed springs of the intermediate grids may become unable to hold the fuel rods straight against the action of the above-mentioned bending moments which now are further enhanced by the axial compression forces acting upon the fuel rods tending to grow. The consequence of these conditions is fuel rod bow which is highly undesirable because it results in a significant departure-from-nuclear-boiling heat transfer penalty and, if extensive enough to cause fuel rods to touch, in accelerated fuel-rod cladding corrosion.

It is the principal object of the invention to alleviate this problem, and ~~the invention~~ accordingly resides in a nuclear fuel assembly including a coolant-inlet end structure, a coolant-outlet end ~~structure, and a~~ plurality of transverse spacer grids disposed between the end structures and adapted to laterally support fuel rods in parallel spaced relationship with respect to each other, said spacer grids comprising a first end grid located nearer to the coolant-inlet end structure, a second end grid located nearer to the coolant-outlet

end structure, and at least one intermediate grid located between said first and second end grids, each of said spacer grids including detents designed to engage the respective fuel rods and to apply to each of them a predetermined force for holding the fuel rod against vibration and lateral displacement thereof, characterized in that said predetermined force designed into the detents of said second end grid is less than said predetermined force designed into the detents of said first end grid, and is insufficient to prevent rectilinear elongation of the respective fuel rods upon axial growth thereof.

This arrangement which, in accordance with the invention, ensures that fuel rods can rectilinearly elongate during axial growth thereof avoids their being placed in axial compression to a degree subjecting the fuel rods to bending moments strong enough to overcome the forces applied by the detents of the intermediate grids in seeking to hold the fuel rods straight. Therefore, and since, in addition, designing lesser detent forces into said second end grid of the fuel assembly also reduces the bending moments inherently induced in fuel rods when detents act thereon in opposition at points axially spaced apart, fuel-rod bow is unlikely to occur even if lateral support of the fuel rods is diminished in the intermediate grid or grids due to irradiation-induced relaxation of the grid detents, especially grid springs.

It will be appreciated, then, that the invention alleviates the problem of fuel-rod bow in fuel assemblies, including fuel assemblies of the "optimized" kind mentioned above, and that it does so without impairing the ability of the detents in the end grid near the coolant-inlet end structure of the fuel assembly to hold the fuel rods firmly against vibration induced by turbulence and cross-flow of the coolant entering the fuel assembly.

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is an elevational view of a nuclear fuel assembly shown in longitudinally foreshortened form;

Fig. 2 is an isometric partial view of one of the spacer grids of the fuel assembly illustrated in Fig. 1;

Fig. 3a is a diagram of forces typically acting upon a fuel rod in a conventional fuel assembly; and

Fig. 3b is a diagram of forces acting upon a fuel rod in a fuel assembly embodying the invention.

Referring now particularly to Fig. 1, the fuel assembly illustrated therein and generally designated with reference numeral 10 is adapted for use in a pressurized water reactor and basically of conventional construction. The fuel assembly 10 comprises a coolant-inlet end structure or bottom nozzle 12 for supporting the assembly in the core region of a nuclear reactor (not shown); control-rod guide tubes or thimbles 14 attached to the bottom nozzle 12 and extending upwards therefrom; transverse fuel-rod spacer grids 16 which are axially spaced along, and attached to, the guide thimbles 14 and adapted to laterally space and support nuclear-fuel rods 18 in an organized array; an instrumentation tube 20 extending through the center of the fuel assembly 10; and a coolant-outlet end structure or top nozzle 22 attached to the upper ends of the guide thimbles 14 so as integrate the various parts into a unitary assembly. Supported in the top nozzle 22 is a conventional rod-cluster control mechanism 28 which includes radial flukes 30 connected to the upper ends of control rods 32, and which is operable so as to vertically move the control rods in the guide thimbbles 14, as well known in the art.

The spacer grids 16 can be classified as divided into three superadjacent categories, namely, a lower or upstream end grid 16L, one or more intermediate grids 16I, and an upper or downstream end grid 16U, the terms "upstream" and "downstream", as employed herein, having regard to the direction of coolant flow through the fuel assembly when in use.

Turning now to Fig. 2 of the drawings, the spacer grid 16 partially illustrated therein is composed of a plurality of inner straps 24 arranged in an egg-crate-like manner to form open cells 34 each adapted to receive one of the fuel rods 18 shown in Fig. 1, and outer or peripheral straps 36 interconnected at their terminal ends and having connected thereto the terminal ends of the inner straps 24. As shown in Fig. 2, the outer straps 36 are of greater height than the inner straps, each of them having a main or intermediate portion 40 and resilient upper and lower border portions 42 and 44, respectively. The upper or downstream border portions 42 may be provided with coolant mixing vanes, as well known in the art.

Each of the fuel-rod receiving cells 34 has associated therewith at least two pairs of oppositely disposed fuel-rod supporting detents, namely, a first pair of detents disposed on two of the four walls of the cell, and a second pair of detents disposed on the remaining two cell walls, and with all of the detents projecting from the respective cell walls toward the longitudinal axis or centerline (as indicated at A in Fig. 2) of the cell. In the illustrated embodiment, there are six fuel-rod supporting detents per cell 34, namely, two pairs of relatively rigid dimples 46 disposed on two adjoining cell walls and with the dimples of each pair spaced apart in the direction of the longitudinal axis A of the cell, and two grid springs 28 each disposed on one of the two remaining cell walls and adapted to engage a fuel rod, when received in the associated cell, at a level intermediate the two dimples on the opposite cell wall.

In the preferred embodiment illustrated herein, and as seen from Fig. 2, the dimples 46 are open to coolant flowing through the respective cells, i.e. they are facing the coolant flow edgewise, and the grid springs 48 are oriented so as to have their edges extend generally in parallel to the coolant-flow through the cells. Preferably, the dimples 46 and springs 48 are formed out of the respective grid straps, and each of them has a fuel-rod supporting surface which is contoured to cradle the fuel rod received in the associated grid cell 34, as disclosed fully in Applicant's European Patent Publication No. 0 198 598. From the following description of the present invention, however, it will be appreciated that the invention per se is applicable as well to fuel assemblies having spacer grids with different designs and orientations of grid springs and dimples.

Each of the spacer grids 16 is fabricated from a material selected according to the most predominant functional concerns pertaining to the particular location at which the grid is intended to be utilized on a fuel assembly. Thus, any spacer grid intended for use on an intermediate portion of the fuel assembly, namely, at a location between the lowermost and uppermost end grids, should be made of a material having as low a neutron-absorption cross-section as possible in order to avoid undue parasitic absorption of neutrons. Accordingly, the spacer grids 16I of the illustrated fuel assembly preferably are made of Zircaloy material which is known for its relatively low neutron-absorption cross-section, and even though grid springs of Zircaloy grids are susceptible to irradiation-induced spring relaxation.

Because there is considerable turbulence and cross-flow of coolant in the lower portion of the fuel assembly 10, it is important that the lowermost grid or upstream end grid 16L be made of a material which is less susceptible to irradiation-induced spring relaxation and, therefore, is capable of maintaining a relatively high spring force on the fuel rods 18 throughout the useful life of the fuel assembly 10. Such a material is Inconel which, therefore, is the preferred material from which to make the lowermost grid 16L, even though it has a higher neutron-absorption cross-section than Zircaloy, a consideration of less concern than spring force at the lowermost grid location.

The material with the superior ability to maintain a high spring force, i.e. Inconel, preferably is used also for the uppermost or downstream end grid 16U which is located at the same general level as the gas-plenum portions of the fuel rods 18 and, therefore, is at the upper fringe of the main neutron-flux region where the parasitic effect of a higher neutron-absorption cross-section is of relatively little concern.

When a fuel rod 18 is located in a cell 34 of a newly formed grid 16, the grid springs 48 and dimples 46 combine to produce an interference fit with the exterior of the rod 18 extending through the cell 34, thereby to support the fuel rod 18 laterally within the cell 34 to frictionally restrain it against axial movement. Because the dimples 46 acting in opposition to the springs 48 and are axially offset from the latter by a distance d(Figure 2), there is created a bending moment (arrow B) which tends to deflect the fuel rod 18. More specifically, each grid spring exerts a spring force F_s perpendicular to the cell axis A, whereas th dimples 46 produce a dimple force F_d in opposition to the spring force but applied to the fuel rod at respective locations above and below the point of application of the spring force F_s Thus, a bending moment B is induced in the rod which is equal to the various forces times the separation d therebetween. This bending moment B alone does not result in objectionable bowing of the fuel rod except when combined with axial compression of the fuel rod coupled with radiation-induced relaxation of the grid springs 48 and dimples 46 in the intermediate grids 16I causing the lateral fuel-rod support to be diminished.

In this context, it is known that a fuel rod 18 tends to grow axially during use thereof in a reactor core. Such growth, if restrained, aggravates bowing of the rod 18, as illustrated in Figure 3A depicting the forces resulting from axial growth in a typical prior-art arrangement, and wherein F_L, F_I, and F_U represent the resulting spring and dimple forces acting upon the fuel rod 18 at the respective lower, intermediate and upper grids. When a conventional fuel assembly 10 is initially fabricated, the forces at all grid locations are generally uniform. However, as the fuel rod ages and the various grids 16 are subjected to high radiation, the spring and dimple forces change permanently. (Changes resulting from high temperature may be ignored for purposes of this explanation, although compensation therefor may be made.) After a selected time period (e.g., one year), the spring forces F_I of the intermediate grid or grids 16I are diminished and become considerably less than each of the lower and upper spring forces F_L and F_U which remain essentially constant. Thus, as the fuel rod 18 tends to grow axially, the frictional forces acting thereon at th upper and lower grid locations 16U and 16L resist elongation of the fuel rod tending to grow, thereby placing it in axial compression. The resultant compressive force F_C axially acting on the fuel rod 18 amplifies the above-mentioned bending moment B, thereby causing the rod to bow or bend laterally against the diminished lateral spring force F_I of the intermediate grids 16I, as indicated at 18'. The bow or deflection D may be sufficient to cause the rod 18 to touch an adjacent fuel rod.

Figure 3B shows a similar force diagram but one obtained when utilizing the invention. In accordance with the latter, the springs and dimples in the various grids are designed such that the as-fabricated lower force F_L is greater than the intermediate force F_I which, in turn, preferably is greater than the upper force F_U at the top of the rod 18. Again, the forces acting on the fuel rod 18 will change after a given time interval (e.g., on year), but because the upper force F_U was initially chosen to be sufficiently less than the lower force F_L to permit fuel rod elongation due to axial growth, little, if any, compressive force is produced on the rod 18 as a result of axial growth. Accordingly, there is essentially no augmentation of any bending moment resulting from the offset nature of the springs 48 and dimples 46. Furthermore, and even though the intermediate spring force F_I on the fuel rod 18 decreases due to radiation-induced spring relaxation, it is still sufficient to hold the fuel rod 18 against objectionable bow because the tendency of the fuel rod 18 to bow is much reduced as compared to the prior arrangement of Figure 3A, owing to the ability of the fuel rod to *rectilinearly elongate during axial growth thereof.*

The following Table I shows various ranges and preferred values of spring forces as designed into grids embodying the invention, and as they exist after one year of use.

TABLE I

Grid	Spring Force	As Fabricated Range/kg.	As Fabricated Preferred Values/kg.	After One Year/kg.
16U	F_U	.5-2	1.5	1.4
16I	F_I	1.5-6	5.0	0.5
16L	F_L	2-6	3.5	2.5

Table II below shows the values of a typical prior-art arrangement in which the spring force in each of the grid elements is listed as fabricated and as existing after one year:

TABLE II

Spring Force	As Fabricated Values/kg.	After One Year/kg.
F_U	3.5	3.4
F_I	3.5	0.35
F_L	3.5	2.5

It is seen that, in the prior art, all the as-fabricated spring forces are about the same, e.g., 3.5 kg. However, after one year, the upper spring force is greater than the lower spring force and much greater than the intermediate spring force, which differences result in bowing. In the embodiment of the invention, the springs of the Zircaloy grids likewise relax during use but since the upper grid 16U initially has a smaller spring force designed into it, it will allow each fuel rod to elongate rectilinearly as it axially grows so that there is little, if any, enhancement of the bending moments on the fuel rods and of their tendency to bow.

Claims

1. A nuclear fuel assembly including a coolant-inlet end structure (12), a coolant-outlet end structure (22), and a plurality of transverse spacer grids (16) disposed between the end structures (12,22) and adapted to laterally support fuel rods (18) in parallel spaced relationship with respect to each other, said spacer grids comprising a first end grid (16L) located nearer to the coolant-inlet end structure (12), a second end grid (16U) located nearer to the coolant-outlet end structure (22), and at least one intermediate

grid (16I) located between said first and second end grids, each of said spacer grids including detents (46,48) designed to engage the respective fuel rods and to apply to each of them a predetermined force for holding the fuel rod against vibration and lateral displacement thereof, characterized in that said predetermined force designed into the detents (46,48) of said second end grid (16U) is less than said predetermined force designed into the detents (46,48) of said first end grid (16L), and is insufficient to prevent rectilinear elongation of the respective fuel rods (18) upon axial growth thereof.

2. A nuclear fuel assembly according to claim 1, characterized in that said forces designed into th detents (46,48) of said second end grid (16U) are less than the forces designed into the detents of said or each intermediate grid (16I).

3. A nuclear fuel assembly according to claim 1 or 2, characterized in that said force designed into the detents (46,48) of said second end grid (16U) is substantially within the range of from 0.5 to 2.0 kg.

4. A nuclear fuel assembly according to claim 3, characterized in that said force designed into the detents of said second end grid (16U) is substantially 1.5 kg.

5. A nuclear fuel assembly according to any one of the preceding claims, characterized in that said force designed into the detents (46,48) of said first end grid (16L) is substantially within the range of from 2.0 to 6.0 kg.

6. A nuclear fuel assembly according to claim 5, characterized in that said force designed into the detents of said first end grid (16L) is substantially 3.5 kg.

7. A nuclear fuel assembly according to any one of the preceding claims, characterized in that said or each intermediate grid (16I) consists of a material having a lower neutron-absorption cross-section and higher susceptibility to radiation-induced relaxation than the material of said first and second end grids (16L, 16U).

8. A nuclear fuel assembly according to any one of the preceding claims, characterized in that said or each intermediate grid (16I) consists of Zircaloy.

9. A nuclear fuel assembly according to claim 7 or 8, characterized in that said first and second end grids (16L, 16U) consist of Inconel.

10. A nuclear fuel assembly according to claim 7, 8 or 9, characterized in that said force designed into the detents (46,48) of said or each intermediate grid (16I) is substantially within the range of from 1.5 to 6.0 kg.

11. A nuclear fuel assembly according to claim 10, characterized in that said force designed into the detents of said or each intermediate grid (16I) is substantially 5 kg.

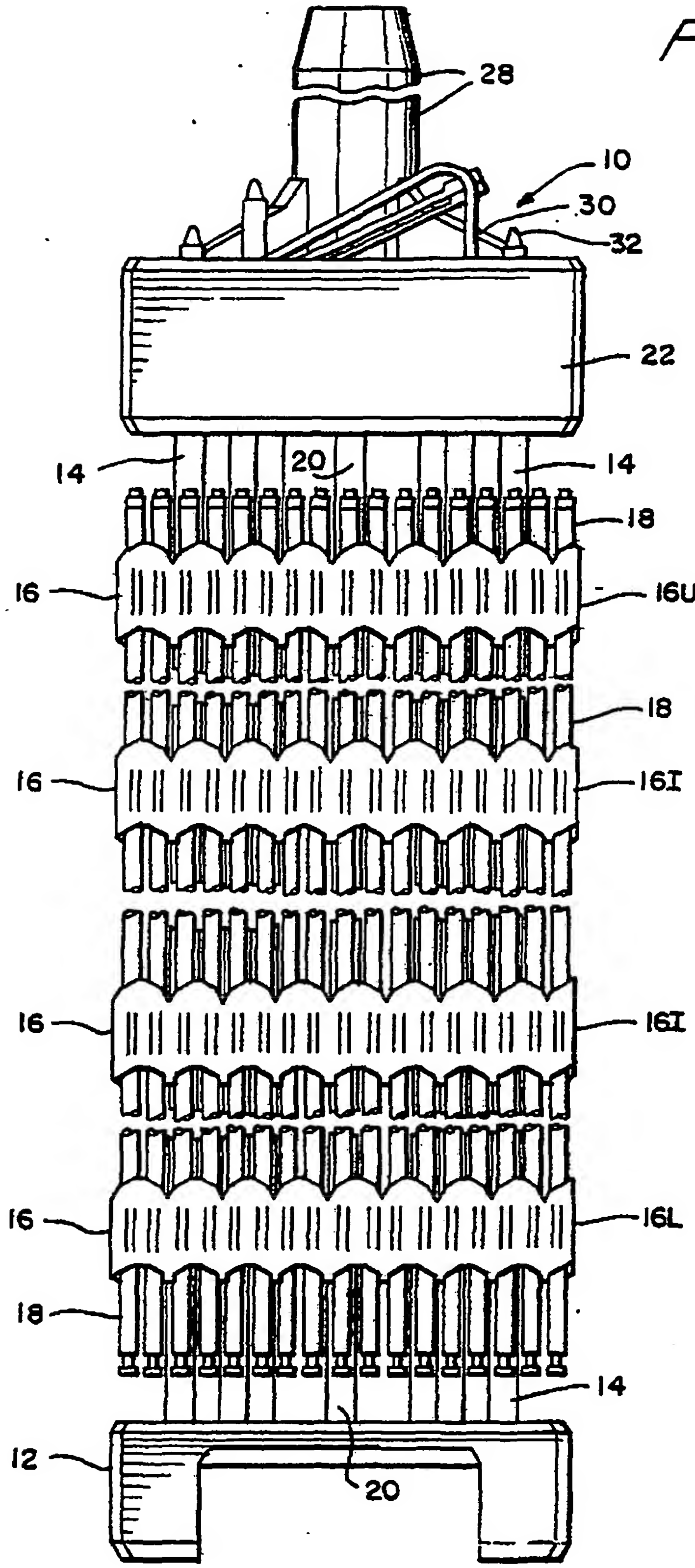


FIG 1

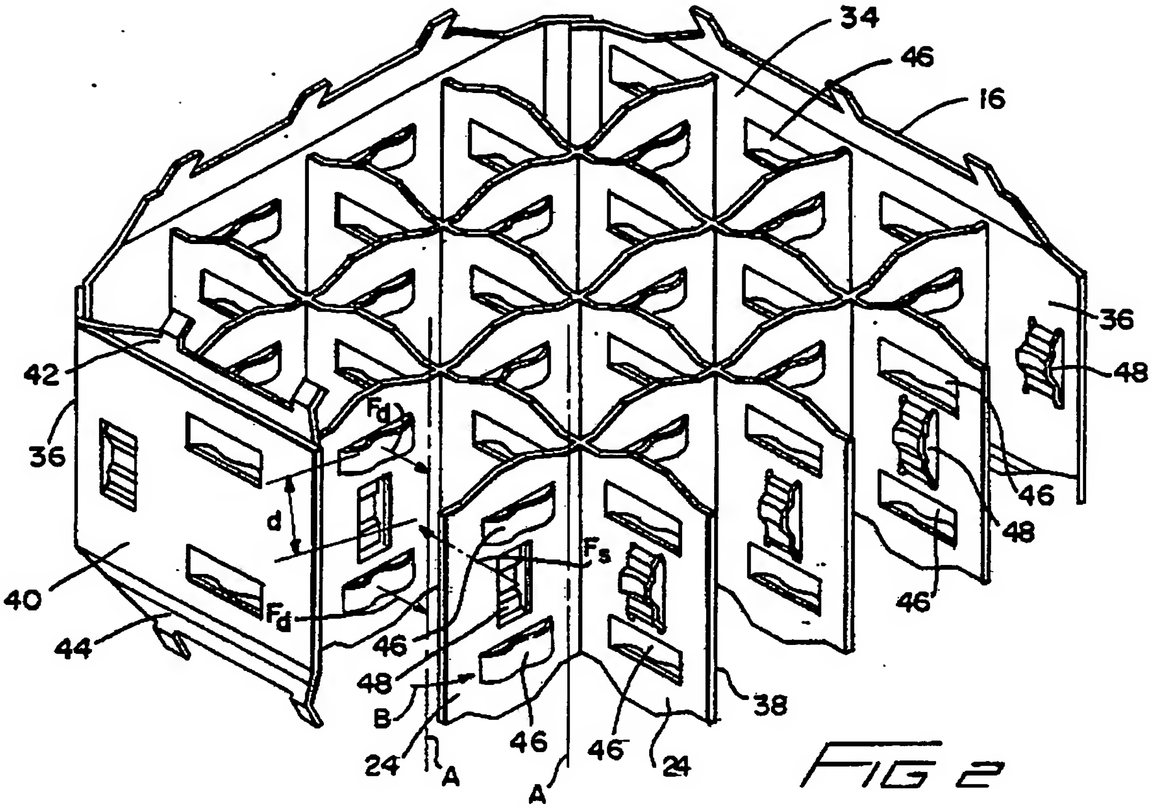


FIG 2

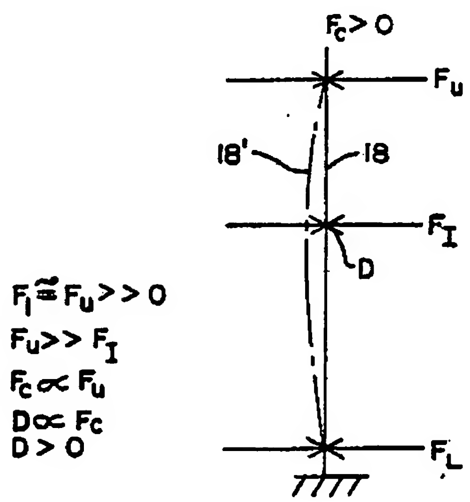


FIG 3A
PRIOR ART

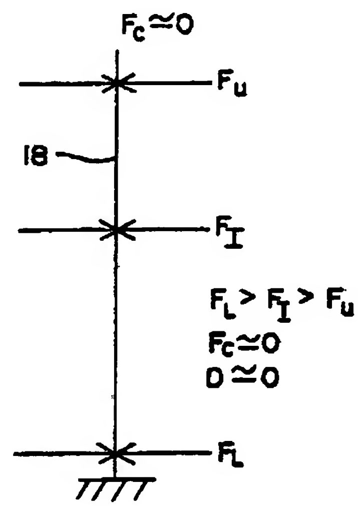


FIG 3B

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) **G brauchsmust r**

(10) **DE 298 08 966 U 1**

(51) Int. Cl.[6]:
G 21 C 3/336

(21) Aktenzeichen: 298 08 966.1
(22) Anmeldetag: 18. 5. 98
(47) Eintragungstag: 10. 9. 98
(43) Bekanntmachung im Patentblatt: 22. 10. 98

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(54) **Abstandhalter für die Brennstäbe eines Druckwasserreaktors**

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Beschreibung

Abstandhalter für die Brennstäbe eines Druckwasserreaktors

Die Erfindung bezieht sich auf einen Abstandhalter mit einer Anzahl von Gittermaschen für die Brennstäbe eines Druckwasserreaktors.

In einem Druckwasserreaktor werden die Brennstäbe, aber auch die Struktur der Brennelemente durch die Kühlmittelströmung zu Schwingungen angeregt. Solche Schwingungen können zu einer Beschädigung der Hüllrohre der Brennstäbe führen. Je nach dem, wie die Lagerung der Brennstäbe in den Abstandhalterzellen vorgenommen ist, ist diese Lagerung mehr oder weniger sensitiv für solche Schäden.

Es hat sich gezeigt, daß dann, wenn die Lagerung eine nennenswerte Dämpfung aufweist, diese Lagerung gegenüber einer Lagerung mit geringer Dämpfung im Vorteil ist.

Es sind verschiedene Lagerungsarten von Brennstäben bekannt. Hierzu zählt beispielsweise die Fünf-Punkt-Lagerung, bei der eine Feder gegenüber von zwei Noppenpaaren angeordnet ist. Hierzu zählt auch die Sechs-Punkt-Lagerung, bei der jeweils eine Feder gegenüber einem Noppenpaar angeordnet ist.

Der Erfindung liegt die Aufgabe zugrunde, einen Abstandhalter für die Brennstäbe eines Druckwasserreaktors anzugeben, bei dem mit einfachen Mitteln eine vergleichsweise große Dämpfung erreicht wird.

Diese Aufgabe wird erfindungsgemäß durch einen Abstandhalter für die Brennstäbe eines Druckwasserreaktors gelöst, bei dem erfindungsgemäß mindestens in einer Gittermasche vorgesehen sind
a) ein Anlageelement für einen Brennstab an einer Seitenwand,

b) ein weiteres Anlageelement für den Brennstab an einer benachbarten Seitenwand und

c) ein einteiliges Federelement mit zwei parallelen Blattfedern, das in einer gegenüberliegenden Ecke angeordnet ist.

Üblicherweise sind die beiden Anlageelemente starr (z.B. als Noppen) ausgeführt.

Hierbei wird also ein einteiliges Federelement mit zwei parallelen Blattfedern eingesetzt. Die beiden parallelen Blattfedern weisen einen gewissen Abstand zueinander auf, und das Federelement ist in einer Ecke der Gittermasche oder Abstandhalterzelle angeordnet. Das Federelement ist bezüglich einer vorgegebenen Symmetrielinie bevorzugt symmetrisch ausgebildet, und die einzelnen Blattfedern liegen rechts und links dieser Symmetrielinie am Hüllrohr in der Gittermasche an; ihre Längsrichtung ist dann parallel zu dem Brennstab der Gittermasche. Jedes Einfedern, wie es bei Schwingungen des Brennstabs auftritt, führt dann zu einer Verschiebung des Auflagepunkts oder der Auflagelinie der Federn an der Hüllrohroberfläche. Diese Bewegung wirkt als (mechanische) Reibungsdämpfung und verstärkt somit die Dämpfung, die bereits durch die Elastizität des Federmaterials auftritt, so daß ein gutes Dämpfungsverhalten sichergestellt ist.

Die Erfindung basiert somit auf der Überlegung, das einteilige Federelement so am Hüllrohr wirken zu lassen, daß aufgrund seiner geometrischen Ausführung bei einem Einfedervorgang zwangsläufig Reibung auftritt, wodurch das gewünschte Dämpfungsverhalten sichergestellt ist.

Ausführungsbeispiele der Erfindung werden im folgenden anhand von drei Figuren näher erläutert. Es zeigen:

Figur 1 einen Brennstab, der durch Noppen und ein Federelement in einer Gittermasche gehalten ist,

Figur 2 einen Blick entlang des verwendeten einteiligen Federelements und

Figur 3 eine schematische Darstellung des Brennstabs bei Verschiebung des Brennstabmittelpunkts infolge einer Einwirkung durch Kühlmittelströmung.

Nach Figur 1 enthält eine Abstandhalterzelle oder Gittermasche 2' eines Abstandhalters für einen Druckwasserreaktor zentral einen Brennstab 4. Dieser Brennstab 4 ist durch drei Strukturen zentral gehalten: An der linken Seitenwand 6 befindet sich innen eine Noppe 8. Bevorzugt sind zwei Noppen 8 übereinander vorgesehen. An der benachbarten (unteren) Seitenwand 10 befindet sich eine weitere Noppe 12. Auch hier können zwei Noppen übereinander vorgesehen sein. Die Noppen 8, 12 sind starr ausgebildet und bestehen jeweils aus einer bandförmigen, aus den Wänden 6 und 10 geformten Struktur. Und in der (oberen) rechten Ecke 20 der Gittermasche 2 befindet sich ein einteiliges Federelement 14, das mit zwei parallelen beabstandeten Blattfedern 14A, 14B an der Oberfläche des Brennstabs 4 anliegt.

Die weiteren Gittermaschen des Abstandhalters können gleichartig ausgebildet sein.

Aus Figur 1 und 2 ergibt sich, daß das Federelement 14 bezüglich einer Symmetrielinie 16 symmetrisch ausgebildet ist. Es besitzt zwei Auswölbungen 18A, 18B, die an der Oberfläche des Brennstabs 4 anliegen. Die in Figur 2 gezeigten Abschnitte a, b und c entsprechen denjenigen von Figur 1.

Das in den Figuren 1 und 2 gezeigte einteilige Federelement 14 sorgt für eine gute Dämpfung infolge von Reibung. Eine solche Reibung tritt auf, wenn - bedingt durch die Kühlmittelströmung - eine Bewegung des Brennstabs 4 stattfindet. Zur näheren Erläuterung ist dazu in Figur 3 angenommen, daß sich

dabei der Mittelpunkt von einer Stelle M1 zu einer Stelle M2 bewegt hat.

Nach der Figur 3 bewegt sich bei einer solchen Bewegung des Brennstabmittelpunkts von M1 nach M2 der Kontaktpunkt bzw. bei Linienanlage die Kontaktlinie. In Figur 3 ist diesbezüglich eine Verschiebung vom Punkt P1 zum Punkt P2 quer zur Feder 14 und quer zur Staboberfläche eingezeichnet. Diese Verschiebung erfolgt unter der Federkraft und führt somit zu einer Reibung, was auf die Schwingung infolge Kühlmittelströmung dämpfend einwirkt.

Im Prinzip kann die auf Reibung basierende Dämpfung noch erhöht werden, wenn die starren Anlageelemente (Noppen) 8, 12 durch federnde Anlageelemente ersetzt werden, insbesondere durch einteilige Federelemente, die ebenfalls jeweils zwei parallele Blattfedern umfassen.

Abschließend sei noch erwähnt, daß das Federelement 14 in der betreffenden Ecke 20 durch mindestens eine umgebogene Lasche 22 befestigt ist.

Schutzansprüche

1. Abstandhalter für die Brennstäbe eines Druckwasserreaktors,
d a d u r c h g e k e n n z e i c h n e t , daß mindestens in einer Gittermasche (2) vorgesehen sind
a) ein Anlageelement für einen Brennstab (4), insbesondere mindestens eine Noppe (8), an einer Seitenwand (6),
b) ein weiteres Anlageelement für diesen Brennstab (4), insbesondere mindestens eine weitere Noppe (12), an einer benachbarten Seitenwand (10) und
c) ein einteiliges Federelement (14) mit zwei parallelen Blattfedern (14A, 14B), das in einer gegenüberliegenden Ecke (20) angeordnet ist.

2. Abstandhalter nach Anspruch 1,
d a d u r c h g e k e n n z e i c h n e t , daß als Anlageelement zwei Noppen (8) und als weiteres Anlageelement zwei weitere Noppen (12) jeweils übereinander angeordnet sind.

3. Abstandhalter nach Anspruch 1 oder 2,
d a d u r c h g e k e n n z e i c h n e t , daß das Federelement (14) in der Ecke (20) durch mindestens eine umgebogene Lasche (22) befestigt ist.

4. Abstandhalter nach einem der Ansprüche 1 bis 3,
d a d u r c h g e k e n n z e i c h n e t , daß das Federelement (14) bezüglich einer Symmetrielinie (16) symmetrisch ausgebildet ist und zwei Auswölbungen (18A, 18B) aufweist, die am Brennstab (4) anliegen.

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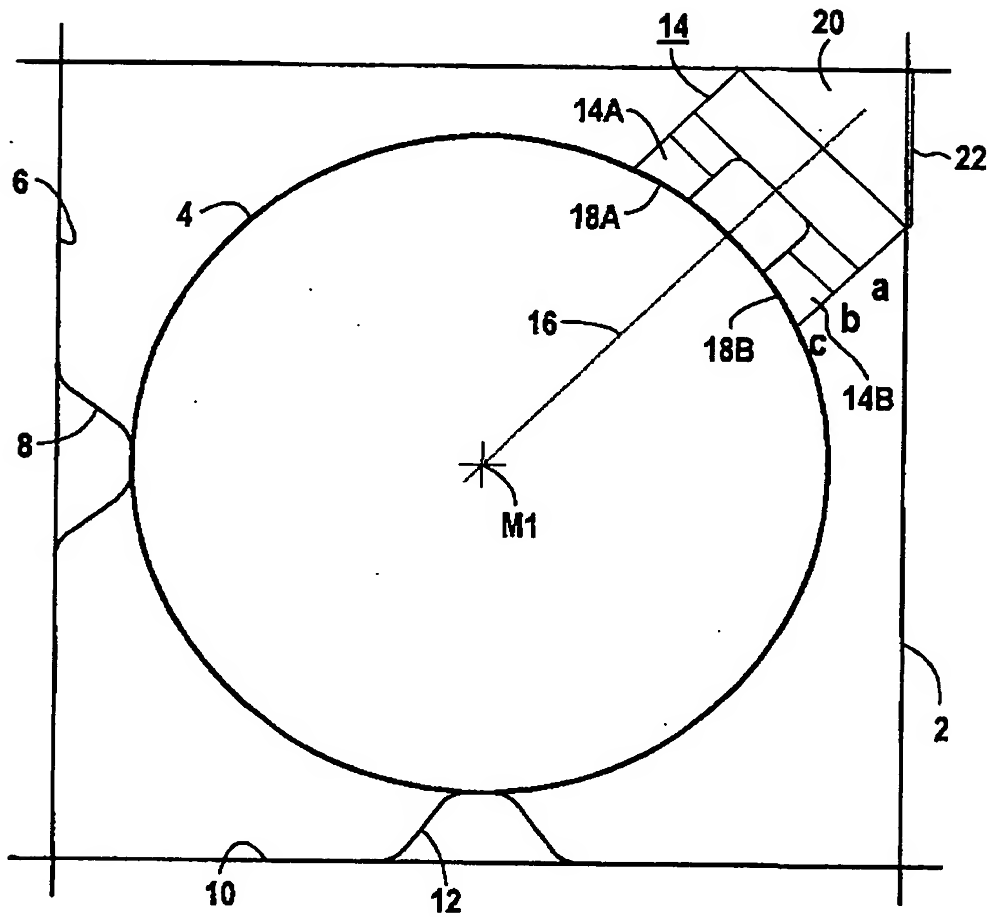

FIG 1

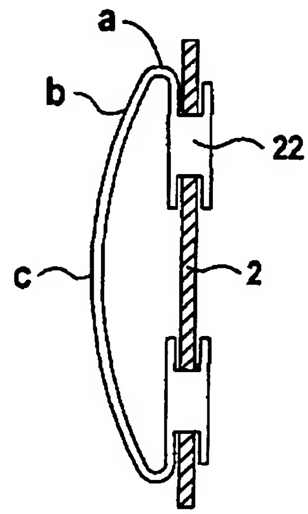

FIG 2

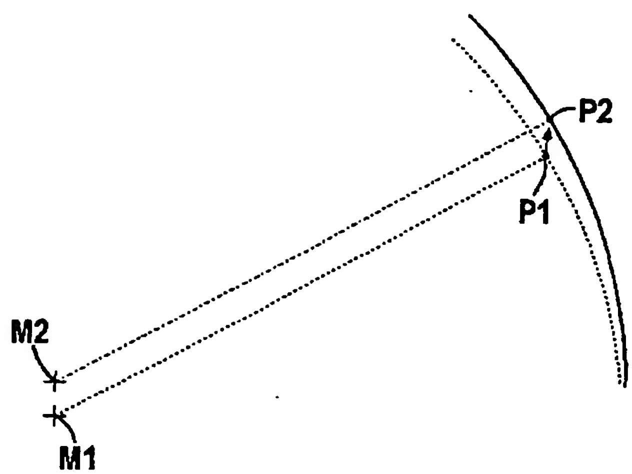

FIG 3